On the Súryaprajñapti.—*By* Dr. G. Thibaut, *Principal, Benares College.*

Part II.

(*Continued from* p. 127.)

Although ancient Indian astronomy was chiefly interested in the moon and although the greater part of the Súryaprajñapti treats of her, especially of the places she occupies at different times in the circle of the nakshatras, a detailed connected account of her motions is not given anywhere, and we must combine the hints we meet with here and there, in order to understand the theory by which the old tírthankáras tried to explain to themselves her motion. In doing this we are of course greatly aided by the full and unambiguous account given of the sun's motion, since it will not be presuming too much that the theory which had been applied to the one luminary would be applied to the other one also. As we have seen above, the sun's daily apparent motion is regarded to be his true one and considered to take place round Mount Meru; his yearly motion is the consequence of his moving more slowly than the stars; his motion in declination is the result of his describing round Mount Meru circles of varying diameter. All this is applied to the moon too. The moon describes (or the two moons describe) circles round Mount Meru at the height of eight hundred and eighty yojanas above the earth, so that her place is eighty yojanas above that of the sun. She moves slower than the stars and slower than the sun; while the latter describes during one yuga 1,830 (or strictly speaking 915) circles, the moon describes only 1,768 (or again on the assumption of two moons 884) such circles; the difference of the two numbers = 62 indicates the number of times the moon enters into conjunction with the sun. During the same period, *viz.*, the quinquennial yuga, the moon completes sixty-seven sidereal revolutions. Each of these revolutions is, analogously to the sun's revolutions, divided into two ayanas, an uttaráyaṇa and a dakshiṇáyana, according as the moon is proceeding towards the north or the south (of the equator as we should add). In reality, it is true, the motion of the moon is much more complicated, as it is not only oblique to the equator, like the ecliptic in which the sun is moving, but also inclined to the ecliptic itself at an angle of about 5°, while moreover at the same time the points in which the moon's path cuts the ecliptic are continually receding. One of the consequences of the revolution of the nodes did, as we shall see below, not escape the observation of the author of the Súryaprajñapti, but he was manifestly unable to account for it by a modification of his theory. According to him the moon, like the sun, simply describes concentric circles round Mount Meru, sometimes approaching it sometimes receding from it. While, however, the period of the sun's progress from and towards Mount Meru comprises one year—the time which the sun employs in arriving again at the same star—the corresponding period of the moon embraces one nakshatra month = 27 days, 9 $\frac{27}{67}$ muhúrtas. From this it is easy to find the number of the circles the moon describes. She performs during one yuga 1,768 complete revolutions, consequently during one nakshatra month $\frac{1768}{67} = 26\frac{26}{67}$ revolutions, and during one ayana or sidereal half month $13\frac{13}{67}$ revolutions. The moon therefore proceeds towards the north during the time which she wants for describing $13\frac{13}{67}$ circles, and after that she proceeds towards the south for the same length of time. From this it follows that, while the sun has 184 different circles to describe, the moon has fifteen such circles only. At the beginning of the yuga she leaves the outermost circle and begins her uttaráyaṇa, describes the thirteen circles intermediate between the outermost and the innermost ones and enters into the fifteenth (innermost) circle, through $\frac{13}{67}$ parts of which she passes. After that the sidereal half moon has elapsed, and the moon has to retrace her steps towards the south. She therefore leaves the innermost circle unfinished, returns into the next one, passes again through the 13 intermediate circles and enters into the 15th (outermost) circle. After she has passed through $\frac{13}{67}$ parts of the latter, the sidereal half moon is again over and the progress towards the north recommences. Thus the moon moves in 15 circles of different diameter, but only 13 she passes through in their entirety while a fractional part only of the two exterior circles are touched by her. We have seen above that the vikampa-kshetra of the sun, *i. e.*, the extent to which the sun moves sideways in his northern and southern progress is estimated at 510 yojanas ($= 183 \times 2\frac{48}{61}$; the latter quantity being the amount of the daily vikampa) ; the vikampa-kshetra of the moon is estimated at nearly the same amount, *viz.*, $509\frac{53}{61}$ yojanas (it has been already remarked that the inclination of the moon's path to the ecliptic is not known to the Súryaprajñapti). The diameter of the moon herself is estimated at $\frac{56}{61}$ yojanas, the interval between consecutive circles described by the moon at $35 + \frac{30}{61} + \frac{4}{7 \times 61}$ yojanas ; the sum of these two quantities is $36 + \frac{25}{61}$

$+ \frac{4}{7 \times 61}$, which multiplied by 14, gives the above stated amount $\left(509 \frac{53}{61}\right)$ as the whole vikampakshetra during one lunar half month. Here—as likewise above with reference to the sun—the Súryaprajñapti does not directly speak of the diameter of the moon, but of the measure of the breadth of the circle described by the moon ; but the two things come to the same. The manner in which the moon, after having completed one of her circles, passes over into the next one is not expressly detailed ; we must imagine it similar to that of the sun.

In connexion with this account of the moon's motion, the Súryaprajñapti enters into a curious calculation, of no practical, and it can hardly be said any theoretical interest, which, however, may be mentioned here as a specimen of the accuracy with which the system is worked out into its minutest details. The question is raised : what circles are common to the sun and moon and how far are those of the moon's circles which belong to the sun also touched by the latter ? As the moon's circles are elevated above those of the sun by the amount of eighty yojanas, strictly speaking not any circle is common to both ; common to both are, however, said to be those circles of the moon which when projected upon the plane in which the sun describes his circles partially or entirely coincide with the latter. The vikampa-kshetras of the two being nearly equal, while 15 circles of the moon correspond to 184 circles described by the sun, the consequence is that the by far greater portion of the sun's circles do not coincide with the moon's circles, but fall into the wide intervals separating the latter, one from another. Thus for instance the first (innermost) circle of the sun coincides with the first circle of the moon, so that when both luminaries move in their innermost circles their distance from Mount Meru is equal ; only the circle of the moon overlaps that of the sun by $\frac{8}{61}$ yojanas, this being the difference of the breadth of the circles described by the two (of the diameters of the two bodies). The next twelve circles of the sun all fall into the interval between the first and the second circle of the moon ; for this interval (plus the overlapping $\frac{8}{61}$ of the first circle) amounts to $35 + \frac{38}{61} + \frac{4}{7 \times 61}$ yojanas, while the vikampa-kshetra of twelve solar circles amounts to $33 \frac{27}{61}$ yojanas only. After that two yojanas are occupied by the interval between the 13th and the 14th solar circles, and then the fourteenth solar circle begins, which therefore partly coincides with the second lunar circle. By continuing these calculations for all lunar circles, it is found that the first up to the fifth inclusive, and again the eleventh up to the fifteenth inclusive are "súrya-sammiśráṇi," *i. e.*, partly coincide with solar circles, while the sixth up to the tenth do not coincide with solar circles, the latter falling entirely into the intervals between the named lunar circles. To reproduce here all the details of the calculation would be purposeless.—That the preceding account of the moon's motion agrees with the ideas of the author of the Súryaprajñapti is to be concluded from the formulas given in different parts of the work for the performance of certain calculations. Thus for instance the question is raised, in what ayana and what circle each parvan takes place, *i. e.*, how many ayanas have elapsed at the different times when the moon enters into conjunction or opposition and in which of the fifteen circles she is moving just then. This question is answered by some ancient gáthás quoted in the commentary, according to which the calculation has to be made as follows. The constant quantity—the ध्रुवराशि—which is to be used for the calculation of each parvan, is equal to $1 + \frac{4}{67} + \frac{9}{31 \times 67}$, *viz.*, of one of the circles described by the moon. This quantity is of course easily found by the following consideration. The moon which describes in one yuga 1,768 circles describes in one parvan $\frac{1768}{124} = 14\frac{8}{31}$ circles and in one ayana $13\frac{13}{67}$ circles; the difference of these two quantities is the above mentioned constant quantity. The rule for finding the places of the parvans is now as follows: The way accomplished by the moon during one parvan being equal to the way accomplished during one ayana plus $1 + \frac{4}{67} + \frac{9}{31 \times 67}$ circles, take at first as many ayanas as the number of the parvan whose place is wanted indicates, multiply then the constant quantity by the number of the parvan, and if the result exceeds $13\frac{13}{67}$, deduct it from this latter quantity (which subtraction if necessary has to be repeated until the remainder is less than $13\frac{13}{67}$); as often as this subtraction is performed as many unities are to be added to the number of ayanas found above and—unless the subtraction leaves no remainder—one additional unity is to be added; add two to the remainder; the resulting sum will indicate the circle in which the moon stands at the parvan. Regarding this latter point it is to be remembered that the circles are to be counted from the innermost circle when the number of the parvan is an even one and from the outermost circle when it is an odd one. To illustrate this let us take one of the many examples given by the Commentator. Required the place of the moon at the fourteenth parvan. Multiply at first one by fourteen, that means: fourteen ayanas have elapsed at the time. Then multiply $1 + \frac{4}{67} + \frac{9}{31 \times 67}$ by fourteen; the result is $14 + \frac{56}{67} + \frac{126}{31 \times 67} = 14 + \frac{60}{67} + \frac{2}{31 \times 67}$. This is the number of circles which the moon has passed through during fourteen parvans in addition to fourteen ayanas. As this number exceeds the number of circles passed through in one ayana $\left(viz., 13 \frac{13}{67}\right)$, the latter number has to be deducted from it and one has to be added to the number of ayanas. So we see that the moon has performed 15 ayanas at the end of the 14th parvan. The remainder left after the above deduction shows the number of circles which the moon has passed through in addition to the 15 complete ayanas; in our case these amount to $1 + \frac{47}{67} + \frac{2}{31 \times 67}$. As there is an excess above 15 complete ayanas, we have according to the rule to add one to their number, *i. e.*, the parvan takes place in the sixteenth ayana. And since the moon enters at the beginning of the ayana into the second circle (the circles being counted from the innermost as well as the outermost) and since in our case the moon has completed more than one full circle, two has to be added to the number of circles found above in order to obtain the ordinal number of the circle in which the moon stands at the expiration of the 14th parvan. The full answer is therefore: the 14th parvan takes place in the sixteenth ayana, in the third circle (reckoning from the innermost circle), $\frac{47}{67} + \frac{2}{31 \times 67}$ of this circle having already been passed through. In the same manner the places of all other parvans may be easily found; the commentator gives the places of parvan I—XV; but it would serve no purpose to extract them here. What has been given will suffice to justify the hypothetical account of the moon's motion detailed above.

The question regarding the relative velocity of sun, moon and stars which is raised in the 15th book finds its answer in accordance with the general principles of the system. The apparent daily motion being considered as the real one, it follows that the nakshatras travel faster than the sun, and the sun again faster than the moon; the space passed through by each of these bodies during a month, day, muhúrta, etc. is calculated and exhibited in detail; we need, however, only remember that the sun describes in one yuga 1,830 circles, while the moon describes only 1,768 and the nakshatras—through whose circle the sun passes five times—describe 1,835. From these relations all special values can be easily derived. It is just mentioned—no details being given—that the planets (graha) travel faster than the sun and the stars (táráḥ) faster than the nakshatras. It is needless to discuss the former of these two assertions; the latter is of course entirely indefensible and no reason leading to it can well be imagined. This is the only time that the stars—excluding the nakshatras—are mentioned in the Súryaprajñapti as far as we can judge from the commentary.

The next point to be considered is the information the Súryaprajñapti furnishes with regard to the nakshatras. Incidentally it has already been remarked that the number of the nakshatras is invariably stated as being twenty-eight, and that the nakshatras are as invariably treated as being of different extent. The particulars are as follows:

According to their extent or, to look at it from another point of view, according to the time during which sun and moon are in conjunction with them, the nakshatras are divided into four classes. Firstly, those with which the moon is in conjunction during one ahorátra = thirty muhúrtas; to this class belong Revatí, Aśviní, Kṛittiká, Mṛigaśiras, Pushya, Maghá, Púrvaphálguní, Hasta, Chitrá, Anurádhá, Múla, Púrváshádhá, S'ravaṇa, S'ravishṭhá, Púrvabhádrapadá. The one ahorátra for which the conjunction lasts may be expressed as $\frac{2010}{67}$ muhúrtas, the convenience of which expression will appear at once. The second division comprises those nakshatras which are in conjunction with the moon for half a nycthemeron = fifteen muhúrtas $= \frac{1005}{67}$ muhúrtas; to this division belong S'atabhishaj, A'śleshá, Bharaṇí, Jyeshṭhá, A'rdrá, Svátí. To the third division belong those nakshatras with which the moon is in conjunction for one and a half nycthemeron $= 45$ muhúrtas $= \frac{3015}{67}$ muhúrtas; these nakshatras are Uttaráshádhá, Uttaraphálguní, Uttara-bhádrapada, Punarvasu, Viśákhá, Rohiṇí. The fourth division comprises one nakshatra only, *viz.*, Abhijit, with which the moon is in conjunction for $9\frac{27}{67} = \frac{630}{67}$ muhúrtas. We see now for what reason the time of conjunction has been expressed throughout in sixty-sevenths of a muhúrta; it was done for the purpose of obtaining homogeneous expressions for all nakshatras. At the same time these fractions furnish us with an easy means for calculating the time during which the sun is in conjunction with each nakshatra; for five revolutions of the sun occupying the same time as sixty-seven revolutions of the moon, we have only to replace the denominator of the above fractions by five. The result of this operation having been turned into nycthemera, we find as the expression for the time during which the sun is in conjunction with the nakshatras of the four divisions the four following terms: 13 days, 12 muhúrtas; 6 days, 21 muhúrtas; 20 days, 3 muhúrtas; 4 days, 6 muhúrtas.—According to the space the nakshatras occupy they are either samakshetra, occupying a mean (medium) field or apárdhakshetra, occupying half a field or dvyardhakshetra, occupying one field and a half. There is no special name for the extent of Abhijit.

In connexion with this division of the nakshatras into different classes according to the space they occupy or the time during which they are in conjunction with the moon, there is another one referring to the time of the day or the night at which they enter into conjunction. This classification is, however, connected with considerable difficulties. It is nowhere clearly stated on the conjunctions of what particular month this division is based; that such a statement ought to have been given, appears from the consideration that the periodical month during which the moon passes through all nakshatras comprises 27 days plus $\frac{27}{67}$ days, and that therefore in the second, third, fourth, etc. months the times at which the moon enters into conjunction with the single nakshatras will all differ from the times of the first month. If for instance the moon at the beginning of the first month enters into conjunction with Abhijit in the early morning, she will at the beginning of the second month again enter into conjunction with it $9\frac{27}{67}$ muhúrtas later, that is, in the afternoon and so on. Other difficulties will appear from the following detailed reproductiou of the Súryaprajñapti's account concerning this point. The nakshatras are either "púrvabhága" *i. e.*, such as enter into conjunction with the moon during the forenoon; or "páschádbhága" *i. e.*, such as enter into conjunction during the afternoon or "naktambhága" *i. e.*, such as enter into conjunction during the night or "ubhayabhága" which term will be explained further on. The nakshatras of the two first classes are the samakshetras, those of the third class the apárdhakshetras, those of the fourth class the dvyardhakshetras. It certainly does not appear why the samakshetras should enter into conjunction with the moon during the day only and the apárdhakshetras during the night only; in reality there is no connexion between the extent of a nakshatra and the time when the moon enters into it. Let us, however, follow the detailed statements about each single nakshatra. The first aphorism of the Súryaprajñapti appears to be "Abhijit and S'ravaṇa are paśchádbhága samakshetra." To this the commentator rightly objects that Abhijit is neither samakshetra, since it occupies only $9\frac{27}{67}$ muhúrtas of the moon's periodical revolution, nor paśchádbhága, since at the beginning of the yuga the moon enters into conjunction with it in the early morning. At the same time he tries to obviate these objections by remarking that Abhijit is called samakshetra and paśchádbhága, because it is always connected with S'ravaṇa to which both these attributes rightly belong, or that it may be called paśchádbhága with a view to conjunctions other than the first one which may take place in the course of the yuga. But these both attempts at reconciling contradictions are very unsatisfactory. Howsoever this may be, the commentator goes on to explain that Abhijit and S'ravaṇa, after having finished their conjunction with the moon, hand her over to Dhanishṭhá at evening (Abhijit-śravaṇo dve nakshatre sáyam-samayád árabhya ekám rátrim ekam cha sátirekam divasam chandreṇa sárddham yogam yuktaḥ etávantam kálam yogam yuktvá tad-anantaram yogam anuparivartayataḥ átmanaś chyávayataḥ yogam chánuparivartya sáyam divasasya katitame paśchádbhága chandram dhanishṭháyáḥ samarpayataḥ). For this reason Dhanishṭhá also is paśchádbhága. After having been in conjunction with it for thirty muhúrtas the moon enters S'atabhishaj at the time when the stars have already become visible (parishphuṭanakshatramaṇḍalávaloke); S'atabhishaj is therefore naktambhága. How S'atabhishaj enters into conjunction at night, while exactly one ahorátra before Dhanishṭhá has been said to enter into conjunction during the afternoon, is not explained. S'atabhishaj being apárdhakshetra, the moon remains in conjunction with it for fifteen muhúrtas only and enters on the next morning into conjunction with Púrva-proshṭhapada, which being samakshetra remains in conjunction during one whole ahorátra. On the following morning the moon enters Uttara-proshṭhapada, which therefore would be púrvabhága. But the matter is looked at in a different light, Uttara-proshṭhapada is dvyardhakshetra, *i. e.*, remains in conjunction for 45 muhúrtas. If we now deduct from this duration the fifteen first muhúrtas and imagine Uttara-proshṭhapada to be samakshetra, the conjunction of the moon with it—looked at as samakshetra—may be said to take place at night and in consequence one—the real—conjunction taking place during the day and the other—the fictitious one—taking place at night the nakshatra is called ubhayabhága (idam kilottarabhádrapadákhyam nakshatram uktaprakáreṇa prátaś chandreṇa saha yugam adhigachchhati, kevalam prathamán pañchadaśa muhúrtán adhikán apaníya samakshetram kalpayitvá yadá yogaś chintyate tadá naktam api yogo 'stíty ubhayabhágam avaseyam). Uttarabhádrapada remains in conjunction for one day, one night and again one day, on the evening of which the moon enters Revatí; Revatí is therefore paśchádbhága. After it has remained in conjunction for one nychthemeron the moon passes into Aśviní at evening time. Aśviní is therefore likewise paśchádbhága. From it the moon passes on the next evening into Bharaṇí, at the time, however, when the stars have become visible and night may be said to have begun; Bharaṇí is therefore naktambhága. Being at the same time apárdhakshetra, the moon leaves it on the next morning to enter Kṛittiká, which therefore is púrvabhága. On the next morning the moon enters Rohiṇí which is dvyardhakshetra and, on account of that, ubhayabhága. Mṛigaśiras which she enters forty-five muhúrtas later at evening is paśchádbhága; A'rdrá which enters into conjunction thirty muhúrtas later, at the time when the stars have come out, is naktambhága; Punarvasu into which the moon enters on the next morning, being dvyardha, is ubhayabhága. Pushya comes into conjunction on the evening of the following day and is paśchádbhága; A'ślesha thirty muhúrtas later, when the stars have come out, and is naktambhága; Maghá and Púrva-phalguní into which the moon enters on the mornings of the two following days are púrvabhága; Uttara-phalguní which comes into conjunction on the morning after that is ubhayabhága, because it is dvyardhakshetra. Hasta and Chitrá enter into conjunction on the evenings of the two following days, before night has set in, and are therefore paśchádbhága. Then again follows one naktambhága nakshatra, *viz.*, Svátí which enters into conjunction after nightfall, and upon this a dvyardhakshetra and consequently ubhayabhága nakshatra, *viz.*, Viśákhá. Then Anurádhá paśchádbhága, after this Jyeshṭhá, apárdhakshetra and naktambhága, remaining in conjunction from nightfall to the morning only; after this two samakshetra and púrvabhága nakshatras, *viz.*, Múla and Púrváshádhá. And finally Uttaráshádhá, which enters into conjunction on the morning, is, however, as a dvyardhakshetra, reckoned among the ubhayabhága. It remains in conjunction for one nycthemeron and the following day, in whose evening the moon arrives at Abhijit whence she had started a (periodical) month ago.

The difficulties involved in all the preceding statements are increased by an assertion made in another chapter of the Súryaprajñapti, *viz.*, that no nakshatra always enters into conjunction with the moon at the same time of the day. This is indeed true, but it contradicts the preceding statements. It may be that this whole classification of the nakshatras according to the time of the day at which they enter into conjunction with the moon is a remainder of an earlier stage of knowledge, when the periodical month was supposed to last just twenty-seven days without an additional fraction, and when it therefore was possible to assign to each nakshatra one fixed hour at which it entered into conjunction during each periodical revolution of the moon. It is true that actual observation would speedily have shown the error of such an assumption, but this remark would apply to almost all hypotheses of the Indians of that period, and we may therefore suppose that in this point too the desire of systematizing prevailed during a certain period over the testimony of the eyes. Later on when the duration of the periodical month had become better known, the old classification lost its foundation entirely and ought to have been dropped; but through the force of custom it maintained its place and was justified some how, although not with the best success, as we have had occasion to observe above.

On the places of the nakshatras with regard to the moon we receive the following information (X. 11). Six nakshatras, *viz.*, Mṛigaśiras, A'rdrá, Pushya, A'śleshá, Hasta, Múla always stand to the south of the moon whenever she enters into conjunction with them. Twelve nakshatras—Abhijit, S'ravaṇa, Dhanishṭhá, S'atabhishaj, Púrva-bhádrapadá, Uttara-bhádrapadá, Revatí, Aśviní, Bharaṇí, Púrva-phálguní, Uttara-phálguní, Svátí always stand to the north of the moon. Seven nakshatras—Kṛittiká, Rohiṇí, Punarvasu, Maghá, Chitrá, Viśákhá, Anurádhá—sometimes stand to the north of the moon entering into conjunction with them; sometimes, however, the moon enters into conjunction with them "pramardarúpeṇa" *viz.*, in such a manner that she passes right through them. To this class, the commentator remarks, some teachers holding an opinion different from that of the Súryaprajñapti add also Jyeshṭhá. Two nakshatras, *viz.*, the two A'sháḍhas stand at the time of conjunction either to the south of the moon or the latter passes right over them. Both these nakshatras consist of four stars each, two of which are situated inside, *viz.*, to the north of the fifteenth circle of the moon, while the two remaining ones are placed outside, *viz.*, to the south of the same circle. Now whenever the moon enters into conjunction with either of the two nakshatras, she passes right between the former pair of stars and may therefore be said to be in conjunction "pramardarúpeṇa." Finally one nakshatra, *viz.*, Jyeshṭhá, always enters into conjunction with the moon pramardarúpeṇa. Regarding the relation of the nakshatras to the fifteen circles of the moon, the following statements are made. Eight circles always are "undeprived" (avirahitáni) of nakshatras. The twelve nakshatras mentioned above, beginning with Abhijit, are in the first circle; in the third circle there are Punarvasu and Maghá; in the sixth, Kṛittiká; in the seventh, Rohiṇí and Chitrá; in the eighth, Viśákhá; in the tenth, Anurádhá; in the eleventh, Jyeshṭhá; in the fifteenth, Mṛigaśiras, A'rdrá, Pushya, A'śleshá, Hasta, Múla and the two Asháḍhás. For although the first six of the last mentioned class in reality move outside the fifteenth circle, they are—the commentator says—so near to it that they may be said to be in it. In order to form a right estimate of the meaning and the value of these statements, we must recall to our mind what has been remarked above about the Súryaprajñapti's theory of the moon's motion. The moon is supposed to proceed alternately towards the south and the north in the same way as the sun does, following—as the Súryaprajñapti seems to assume—the same path; that she in addition to the movement in declination has a movement in latitude, and that the points in which her orbit cuts the ecliptic are continually receding is ignored, theoretically at least, although it had been observed that the position of the moon with regard to some nakshatras is different at different times, that she sometimes passes on the north or south-side of a constellation and at other times moves right through it. Now comparing the particulars with the information given about the position of the nakshatras in the Siddhántas, we find that the Súryaprajñapti agrees with the latter with regard to five out of the six nakshatras said always to stand south of the moon (Mṛigaśiras, A'rdrá, A'śleshá, Hasta, Múla), the latitude of all of them considerably exceeding the highest latitude the moon ever reaches. The case lies differently with regard to Pushya, which according to the Siddhántas lies in the ecliptic, so that it almost appears as if the Pushya of the Súryaprajñapti were an altogether different asterism. From among the twelve nakshatras said to stand always north of the moon ten (Abhijit, S'ravaṇa, S'ravishṭhá, Púrva-Bhádrapadá, Uttara-Bhádrapadá, Aśviní, Bharaṇí, Púrva-Phálguní, Uttara-Phálguní, Sváti) may be identified with the nakshatras of the Siddhántas whose latitudes—excluding Abhijit—vary from 9° to about 39° north. Strange it is only that these nakshatras occupying a zone of about 21° breadth are said to be in one and the same circle of the moon, and still stranger that Abhijit too is classed among them, the latitude of the latter—if identical with the Abhijit of the Siddhántas—exceeding the latitudes of the other nakshatras, with which it is here thrown into one class, by about 30°. The S'atabhishaj and Revatí of the Siddhántas are situated in and close to the ecliptic ; here too therefore we might doubt if the Súryaprajñapti denotes by these two names the same stars as the Siddhántas. The remaining nakshatras may be identified with those of the Siddhántas, the latitude of none of the latter much exceeding the greatest latitude reached by the moon ; a considerable margin must of course be allowed for the inaccuracy of the observations on which the statements of the Súryaprajñapti are based. Quite unfounded is the statement about the moon always passing right through Jyeshṭhá ; it looks as if it had originated at some period when one of the moon's nodes had about the same longitude as that asterism.

The order of succession of the nakshatras is treated in X. 1. Of five different pratipattis regarding this point the author details only one, *viz.*, that one according to which Kṛittiká stands first. The author of the Súryaprájñapti for his part calls Abhijit the first nakshatra, since according to his system at the beginning of the yuga on the day of the summer solstice early in the morning the moon which is full at that time stands in Abhijit. He therefore altogether abandons the principle, sometimes followed, according to which the enumeration of the nakshatras begins with that nakshatra in which the sun stands on the day of the vernal equinox ; if he too had chosen this principle he would of course have begun his enumeration with Aśviní. It may here be mentioned by the way that the Súryaprajñapti does not occupy itself at all with the equinoxes, the name of which is not even mentioned in the whole work.

We now proceed to consider some specimens of the numerous calculations, rules for the performance of which are contained in the Súryaprajñapti itself as well as in a great number of old karaṇa-gáthás quoted by the commentator; remarking at once that the rules contained in the gáthás presuppose exactly the same system as the rules of the Súryaprajñapti itself. A comparison of these calculations with those contained in the jyotisha-vedáñga shows the extreme likeness and in many cases the complete identity of the two sets; a result which supplies another reason for looking on the Súryaprájñapti as—in all essential points—a fair representative of Indian astronomy anterior to the period of the Siddhántas. Several of these calculations have already been reproduced above incidentally; in the following a detailed account of the more important ones among those not yet touched upon will be given.

It appears that before the influence of Greek astronomy made itself felt in India, the division of the sphere into 27 or 28 nakshatras was the only one employed and that no independent subdivisions of the nakshatras were made use of. This want was, however, supplied by a simple transfer of the subdivisions of time to the nakshatras. In accordance with this principle the Súryaprajñapti divides the sphere into 819 $\frac{27}{67}$ muhúrtas, this being the duration of the periodical revolution of the moon, and allots to each nakshatra a certain number of muhúrtas according to its greater or smaller extent. Fixed subdivisions of the muhúrta such as are commonly met in Indian astronomical works are, however, nowhere employed by the author of the Súryaprajñapti; he apparently preferred to keep himself perfectly free from restrictions of this kind and uses throughout those fractions of the muhúrta only which were immediately suggested by the various calculations in hand. From the general nature of the yuga it is manifest at once which fractions will present themselves most readily; they are sixty-seconds and sixty-sevenths ($62 =$ number of synodical months in a yuga, $67 =$ number of periodical months) and, whenever lunar months of both kinds enter into the calculations, sixty-sevenths of sixty-seconds.

One of the most important rules is that which teaches how to find the place of the moon on any parvan. In the following the details of the calculation furnished by the commentator will be stated in extenso, so that at least one complete specimen of computations of this kind may be exhibited.—If we wish to devise a rule for calculating the place of the moon in the circle of the nakshatras at any parvan, we must at first find the constant quantity—the dhruvaráśi—entering as a multiplicand into all calculations of this kind. This in our case is clearly the space passed through by the moon during the lunar month, or more simply, because entire revolutions which bring the moon back to the same place can be neglected, the excess of the lunar synodical month above the periodical month. From what is known about the general constitution of the yuga this quantity is of course readily found to be equal to $66 + \frac{5}{62} + \frac{1}{62 \times 67}$. The commentator calculates this quantity as follows. If the sun performs during 124 parvans five complete revolutions, how much does he perform during 2 parvans (= one synodical month); answer: $\frac{5 \times 2}{124} = \frac{5}{62}$ rev. This therefore is the excess of the synodical month above the periodical one. In order that the division can be carried out, the $\frac{5}{62}$ rev. are turned into nakshatras by multiplying them by $\frac{1830}{67}$ (*i. e.* by $27 \frac{21}{67}$, the duration in ahorátras of the periodical month or, if we like, the extent of the nakshatras; 27 entire nakshatras plus the fractional nakshatra Abhijit). Result of the multiplication $\frac{9150}{4154}$. Again—in order to turn the days or nakshatras into muhúrtas—the numerator is multiplied by 30. Result $= \frac{274500}{4154}$. This division being performed gives as result 66 muhúrtas. The remainder 336 is multiplied by 62 and the product again divided by 4154. Result $= \frac{5}{62}$ muhúrtas. The remainder—62—should again be multiplied by 67 (the fractions employed being throughout sixty-seconds and sixty-sevenths) and divided by 4154; but 4154 being itself $= 62 \times 67$, it is seen at once that the result is 1. Thus the whole quantity is $66 + \frac{5}{62} + \frac{1}{62 \times 67}$ muhúrtas. If now the place of the moon at any amávasyá or púrṇamásí is wanted, the above quantity has to be multiplied by the number of the parvan; for instance, by one if the moon's place at the first full moon after the beginning of the yuga is wanted. The product shows how far the moon at the time has advanced beyond the place she had occupied at the beginning of the yuga, if full moons are concerned, or beyond the place she had occupied at the new moon preceding the beginning of the yuga, if new moons are concerned, (the new moon immediately antecedent to the beginning of the yuga having been selected as starting-point for all calculations concerning new moons). So far the place of the moon is expressed in muhúrtas only; now in order to find from these the nakshatra in which the moon stands at the time, we should have to deduct from the muhúrtas found the extent of all the nakshatras through which the moon has passed one after the other, until the sum would be exhausted. Thus, for instance, if we wanted to find the place of the moon at the third new moon after the beginning of the yuga, the constant quantity $66 + \frac{5}{62} + \frac{1}{62 \times 67}$ would have to be multiplied by 3, so that we should have $198 + \frac{15}{62} + \frac{3}{62 \times 67}$ muhúrtas. Now the moon standing at the new moon preceding the beginning of the yuga in Punarvasu, of which she has still to pass through $22 \frac{46}{62}$ muhúrtas, we should have to deduct this last quantity from $122 + \frac{10}{62} + \frac{2}{62 \times 67}$; from the remainder we should have to deduct 30 muhúrtas (the extent of Pushya); from the remainder again 15 (A'sleshá); again from the remainder 30 (Maghá), and so on, until in the end the fact of the remainder being smaller than the next following nakshatra would show that new moon takes place in that nakshatra.—In order, however, to shorten this somewhat lengthy process, certain subtrahends are formed out of the sum of the extent of several nakshatas, which materially alleviate the work by substituting one subtraction for a number of subtractions. Thus with reference to new moon—the subtrahend (śodhanaka) for Uttara-phálguní is said to be 172, for Viśákhá 292, for Uttara-áshádhá 442; *i. e.*, if from the product of the constant quantity by the number of the new moon 172 can be deducted, we see at once that the moon has advanced beyond Uttara-ashádháḥ; if 292 can be deducted, she has passed the limits of Viśákhá and so on. The subtrahends are not carried on from Punar-vasu beyond Uttara-áshádhá, but make a fresh start from Abhijit, apparently in order to make them available for the calculation of the places of the full moons too. Thus the subtrahend for Abhijit is 9 and a fraction, of Uttara-bhádrapadá 159, of Rohiṇí 309, of Punarvasu 399, of Uttara-phálguní 549, of Viśákhá 669, of Múla 744, of Uttara-ashádhá 819.

The places in which the different full moons of the yuga occur are found by an exactly similar proceeding; only all calculations have to start not from Punarvasu, but from the beginning of Abhijit where the first full moon which coincides with the beginning of the yuga takes place. The text enumerates the places of all full moons and new moons of the yuga at length, carrying in each case the calculations down to sixty-sevenths of sixty-seconds of muhúrtas. It is needless to reproduce these lists here in extenso, as any place wanted can be calculated with ease from the general rule given above.

The same result, *viz.*, to find the place of the moon on a given parvan is obtained by following another rule contained in some gáthás quoted by the commentator. Their purport is as follows. Multiply sixty-seven (the number of periodical revolutions which the moon makes during one yuga) by the number of the parvan the place of which you wish to find and divide this product by one hundred and twenty-four (the number of parvans of one yuga). The quotient shows the number of whole revolutions the moon has accomplished at the time of the parvan. The remainder is to be multiplied by 1830 (*viz.*, 1830 sixty-sevenths which is the number of nycthemera of one periodical month) or more simply by 915 (reducing 1830 as well as the denominator *viz.*, 124 by two). From the product (remainder multiplied by 915) deduct 1302, which is that part of a whole revolution which is occupied by Abhijit (Abhijit occupies $\frac{21}{67}$ days, but as this amount is to be deducted from the numerator of a fraction the denominator of which is 62, 21 is to be multiplied by 62; product $= 1302$). The portion of Abhijit, from which the moon's revolutions begin, is deducted at the outset, because it is greatly smaller than the portion of all other nakshatras and would disturb all average calculations. After it is has been deducted the remainder is divided by 67×62; the quotient shows the number of nakshatras beginning from S'ravaṇa which the moon has passed through, in addition to the complete revolutions. The remainder is again multiplied by thirty, the product divided by 62; the quotient shows the number of muhúrtas during which the moon has been in the nakshatra in which she is at the time. And so on down to small fractions of nakshatras. The following is an example. Wanted the place of the moon at the end of the second parvan. Multiply 67 by 2; divide the product by 124. The quotient (1) indicates that the moon has performed one complete periodical revolution. The remainder (10) is multiplied by 1830 or more simply by 915 (see above); from the product (9150) the portion of Abhijit (1302) is deducted. The remainder (7848) is divided by $67 \times 62 = 4154$; the quotient (1) shows that after Abhijit the moon has passed through one complete nakshatra, *viz.*, S'ravaṇa. The remainder (3694) is multiplied by 30; the product (110820) again divided by 4154; the quotient (26) shows that the moon has moreover passed through 26 muhúrtas of S'ravishṭhá. By carrying on this calculation we arrive at the result that at the end of the second parvan the moon stands in S'ravishṭhá, of which she has passed through $26 + \frac{42}{62} + \frac{2}{62 \times 67}$ muhúrtas.

Analogous calculations are made for the sun too. For instance, in what circle does the sun move at the time of each parvan? The rule here is very simple. Multiply the number of the parvan by fifteen (the number of tithis of one parvan) and from the product deduct the number of avamarátras (excessive lunar days) which occur during the period in question. If the parvan occurs during the first ayana of the sun, the remainder immediately indicates the number of the solar circle which is in fact the same as the number of the civil day on which the parvan happens ; if the parvan takes place during one of the other nine ayanas, the remainder must at first be divided by 183 (number of circles described by the sun during one ayana) ; etc. The rule is simple and needs no illustration.

The rule for finding the nakshatra in which the sun stands at the time of each parvan (the súryanakshatra) is quite analogous to the rule given above for the moon. The sun makes in one yuga five complete revolutions, in one parvan $\frac{5}{124}$ revolutions. This quantity is to be multiplied by the number of the parvan and then we have as above to descend by continued multiplication and division to nakshatras, sixty-second parts of nakshatras and sixty-seventh parts of sixty-second parts. Instead of deducting the portion belonging to Abhijit at the beginning of which the moon stands on the first day of the yuga, we have to deduct that part of Pushya which the sun has not yet passed through at the beginning of the yuga ; it amounts to $\frac{44}{67}$ of a nychthemeron. All the remainder of the calculation is the same as in the moon's case and illustrative examples are therefore not wanted.

Besides there is another and considerably simpler method for finding the sun's place at the end of a parvan ; it is likewise contained in some old karaṇa-gáthás. The rule again assumes a " dhruvaráśi", a constant quantity, to be used in all calculations of this kind. This quantity is $33 + \frac{2}{62} + \frac{34}{62 \times 67}$ muhúrtas ; for if we divide the whole circle of the nakshatras into $819\frac{27}{67}$ muhúrtas (which is the time occupied by a complete revolution of the moon) the above amount expresses the way the sun accomplishes during one parvan. This quantity has therefore to be multiplied by the number of the parvan required, and by subtracting from the product at first the $19 + \frac{43}{62} + \frac{33}{67 \times 62}$ muhúrtas belonging to Pushya, after that the 15 muhúrtas of Áśleshá, after that the 30 muhúrtas of Maghá etc., we find in the end the nakshatra in which the sun completes the parvan. In order to facilitate these somewhat lengthy subtractions, the muhúrtas of a certain number of nakshatras are again added and presented in a tabular form. So for instance 139 muhúrtas (19 + 15 + 30 + 30 + 45) lead us up to the end of Uttara-phálguní, and if therefore the product found in the manner shown above exceeds 139, we may at once subtract 139 instead of performing five separate subtractions and know that the sun has at the time passed beyond Uttara-phálguní. The procedure is analogous to the one described above and needs no further illustration.

For finding how many seasons have elapsed on a certain tithi, the commentator quotes some gáthás of the old teachers. The rule they contain is as follows Multiply the number of the parvans which have elapsed since the beginning of the yuga by fifteen, and add to the result the number of tithis which have elapsed in addition to the complete parvans; deduct from this sum its sixty-second part; multiply the remainder by two and add to the product sixty-one; divide the result by one hundred and twenty-two; the quotient shows the number of seasons elapsed (which when exceeding six will have to be divided by six, since so many seasons constitute a solar year); the remainder divided by two shows the number of the current day of the current season. This rule seems not very well expressed, although it may be interpreted into a consistent sense. At first it must be remembered that the yuga does not begin with the beginning of a season, but with the month śrávaṇa, while the current season—the rainy season—has begun a month earlier with ásháḍha. The calculation would hen, strictly expressed, be as follows. Take the number of parvans which have elapsed since the beginning of the yuga, add to it the tithis which have elapsed of the current parvan and add again to this sum $30\frac{1}{2}$ tithis (the tithis of ásháḍha plus half a tithi of the month preceding ásháḍha) and deduct from this sum its sixty-second part, *viz.*, the so-called avamarátras, *i. e.*, the lunar days in excess of the natural days (according to the Súryaprajñapti's system each sixty-second tithi is an avamarátra). The remainder of the calculation needs no explanation; the formula enjoins the addition of 61 instead of $30\frac{1}{2}$ and division by 122 instead of 61 (the number of days of a season) in order to get rid of the fractional part of $30\frac{1}{2}$.

In order to find the number of the parvan during which an avamarátra occurs and at the same time the tithi itself which becomes avamarátra, the following rule is given. The question is assumed to be proposed in the following manner. In what parvan does the second tithi terminate while the first tithi has become avamarátra, or in what parvan does the third tithi terminate while the second is avamarátra? and so on, (kasmin parvaṇi pratipady avamarátríbhútáyám dvitíyá samáptim upayáti, etc.) The answer is: if the number of the tithi which becomes avamarátra is an odd one, one has to be added to it and the sum to be multiplied by two; the result shows the number of parvans elapsed before the first tithi becomes avamarátra. If the number is an even one, one is added to it, the sum multiplied by two, and to the product thirty-one is added; the result again shows the number of parvans elapsed. Thus for instance if it is asked: when does the first tithi become avamarátra? add one to one (number of the tithi) result two; this multiplied by two gives four; therefore pratipad is avamarátra in the fifth parvan, after four parvans have elapsed. Or again it may be asked: when does the second tithi become avamarátra? add one to two; result three; this multiplied by two gives six, to which thirty-one are added. The result—thirty-seven—shows that in the thirty-eighth parvan the second tithi is avama-rátra. Thus all the avama-rátras for the first half of the yuga are found and the same numbers recur during the second half. The rationale of this rule is obvious.

A simple rule is given for finding the tithis on which the ávṛittis of the sun, *i. e.*, the solstices take place. Multiply the number of the solstice whose date you wish to know by 183 and add to the result three plus the number of the solstice; divide this sum by fifteen; the quotient shows the number of parvans elapsed, the remainder the number of the tithi of the current parvan. This rule—being based on the relation of tithis to sávana days needs no explanation. The following list for the whole yuga results from these calculations.

1st Summer solstice (= 10th solstice of the preceding yuga).	1st dark half of śrávaṇa.
1st Winter solstice,........................	7th „ „ „ mágha.
2nd S. S.,..................................	13th „ „ „ śrávaṇa.
2nd W. S.,..................................	4th light half of mágha.
3rd S. S.,..................................	10th „ „ „ śrávaṇa
3rd W. S.,..................................	1st dark half of mágha.
4th S. S.,..................................	7th „ „ „ śrávaṇa.
4th W. S.,..................................	13th „ „ „ mágha.
5th S. S.,..................................	4th light half of śrávaṇa.
5th W. S.,..................................	10th „ „ „ mágha.

The places which the sun occupies in the circle of the nakshatras at the time of the solstices have been mentioned before; the places of the moon at the same periods can of course be easily calculated when it is remembered that at the beginning of the yuga the moon just enters Abhijit. It is unnecessary to reproduce here the rule given for that purpose; it may only be mentioned that the $\frac{7}{10}$ of a sidereal revolution which the moon performs during one solar ayana in excess of six complete revolutions constitute the "dhruva ráśi" for our case. The Súryaprajñapti likewise states the places in which the lunar ávṛittis take place; from the circumstance that at the beginning of a yuga the moon is full in the first point of Abhijit and at the same time commences her progress towards the north, it follows that her next progress towards the south takes place exactly on the same spot on which the sun was standing at the beginning of the yuga. At all following lunar ávṛittis the places of the two first ones of course recur.

Incidentally another rule is mentioned which certainly was of frequent application, *viz.*, how to find on what natural day and at what moment of time during that day a given tithi terminates. The rule which is contained in an old karaṇa-gáthá is of course very simple. Add together all tithis which have elapsed from the beginning of the yuga up to and including the tithi in question; divide this sum by sixty-two; multiply the remainder by sixty-one and divide again by sixty-two. The remainder is then the wanted quantity. The first division by sixty-two has the purpose to shew by its quotient—the number of complete avamarátras elapsed since the beginning of the yuga; this number has therefore to be deducted from the number of tithis elapsed. The remainder of the above division shows the number of tithis which have elapsed since the occurrence of the last avamarátra; to find by how much they remain behind the same number of natural days, they are multiplied by 61 and divided by 62 (61 natural days = 62 tithis); the remainder then indicates how many sixty-second parts of the current natural day have elapsed at the moment when the tithi in question terminates.

Another old rule has the purpose of teaching how to find the number of muhúrtas which have elapsed on the parvan-day at the moment when the new parvan begins. When the number of the parvan divided by four yields one as remainder (in which case it is called kaly-oja) we must add ninety-three to it; if divided by four it yields two (in which case it is called dvápara-yugma), we add sixty-two to it; if it yields three (tretá-oja), we add thirty-two; if there is no remainder (kṛita-yugma), we add nothing. The sum which we obtain in each case is halved, then multiplied by thirty, finally divided by sixty-two. The quotient shows the number of muhúrtas of the parvan-day which have elapsed at the moment when the new parvan begins. The rationale of this rather ingenious rule is as follows. The duration of one parvan is $14\frac{94}{124}$ days. The first parvan therefore terminates when $\frac{94}{124}$ of the day $= \frac{94 \times 30}{124} = \frac{47 \times 30}{62}$ muhúrtas have elapsed. The number 94 may be obtained by adding 93 to 1, the number of the first parvan. The second parvan ends $29\frac{64}{124}$ days after the beginning of the yuga; 64 equals $62 + 2$, the number of the second parvan. The third parvan terminates $44\frac{34}{124}$ days after the beginning of the yuga; 34

equals 31 + 3, the number of the third parvan. The fourth parvan terminates $59 \frac{4}{124}$ days after the beginning of the yuga; 4 without any addition is the number of the parvan. The fifth parvan again terminates $73 \frac{98}{124}$ days after the beginning of the yuga; 98 is equal to 93 + 5, the number of the parvan. And so on through the whole yuga.

The above examples fairly represent the more important rules contained in the Súryaprajñapti. Now it will be apparent to every one who is to some extent familiar with the Jyotisha-vedánga* that the rules contained in the, as yet partly unexplained, verses of the latter refer to calculations exactly analogous to those contained in the Súryaprajñapti and the old gáthás quoted by the commentator.

From this it might be concluded that it is now easy for us to explain whatever has up to the present remained unexplained in the Vedáñga, possessing as we doubtless do a clear insight into the general nature of the calculations for which it furnishes rules. But close as the connexion between the contents of the two treatises manifestly is, there are two reasons which preclude the direct application of the rules of the Súryaprajñapti to the elucidation of the Vedáñga. In the first place the Vedáñga divides the sphere into twenty-seven nakshatras only and, as far as has been ascertained up to the present, these twenty-seven nakshatras are considered to be of equal extent; while as we have seen above the Súryaprajñapti throughout employs the division of the sphere into twenty-eight nakshatras of unequal extent. In the second place the starting point for all calculations (*viz.*, the places of the winter and summer solstice) is not the same in the two works. The consequence of these two fundamental discrepancies is that although the questions treated of are essentially the same and although the modes of calculation are strictly analogous the results arrived at in the two treatises necessarily differ in all cases, that for instance the place of a certain full or new moon during the quinquennial yuga can never be the same according to the Súryaprajñapti as it is according to the Vedáñga, etc. Nevertheless it is highly probable that somebody who should apply himself to the study of the obscure portions of the Vedáñga after having made himself thoroughly conversant with the contents and methods of the Súryapra-

* Since the publication of the paper on the Jyotisha-vedáñga in the 46th volume of this Journal, the writer has received some very important contributions to the explanation of the Vedánga from Dr. H. Oldenberg, the well-known editor of the Vinaya-piṭakam, who working altogether independently had succeeded in explaining a number of hitherto obscure rules. The writer intends to revert to the Vedánga before long and will then avail himself of the new results most kindly placed at his disposal by Dr. Oldenberg.

jñapti, would succeed in solving some more of the riddles presented to us by the former work.

It must be remembered that there is no indissoluble connexion between that part of the system of the Súryaprajñapti, which might be called the chronometrical one, *viz.*, the doctrine of the quinquennial yuga and its various subdivisions and that part which propounds the theories accounting for the apparent motions of the sun and the moon; it might therefore be that the Vedáñga agrees with the Súryaprajñapti only in the former point and follows a different course with regard to the latter. There occurs, however, one expression in the Vedáñga which makes it appear likely that the analogy between the two books extends to the second point also, *viz.*, the "súryamaṇḍaláni" mentioned in verse 22.

अतीतपर्वभागेभ्यः शोधयेद् द्विगुणां तिथिम् ।
तेषु मण्डलभागेषु तिथिनिष्ठां गतो रविः ॥

It certainly looks as if by these "sun circles" in which the sun is said to be at the end of a tithi, we had to understand daily circles of the same kind as those which, according to the Súryaprajñapti, the sun describes round Mount Meru.

A few words may here be added on the principal feature common to the cosmological systems of the Puráṇas, Buddhists and Jainas, *viz.*, the doctrine of sun, moon and constellations revolving round Mount Meru. In order rightly to judge of these conceptions we must remember that they arose at a time when the idea of the sphericity of the earth had not yet presented itself to the Indian mind, at a time (—if we may assume that the Puráṇic-Buddhistic cosmological system is not later than the period of the rising of Buddhism—) when this then truly revolutionary idea first suggested itself to the early Greek philosophers. And if we carry our thoughts back to that early stage of the development of scientific ideas and try to realize the conceptions which then were most likely to present themselves to enquirers, the old Indian system will lose much of its apparent strangeness and arbitrariness. How indeed could men ignorant of the fact that the earth is a sphere freely suspended in space explain to themselves the continually recurring rising and setting of the heavenly bodies? what could their ideas be regarding the place to which sun and moon went after their setting, and the path which unseen by man they followed so as to return to the point of their rising? Certainly the difficulty was a very great one to those as well who had some vague notion about the earth extending in all directions to an unlimited distance as to those who imagined it to be bounded at a certain distance by a solid firmament surrounding and shutting it in on all sides. We may recall, as one of the fancies to which the difficulty of this question gave rise, the old poetical idea, preserved, for instance, in a beautiful fragment of Stesichorus, of Helios when he has reached Okeanos in the west embarking in a golden cup which carries him during the night round half the earth back to the east whence he rises again. Under these circumstances we must admit that the old Indian idea of the constitution of the world, according to which the rising and setting of sun, moon and stars is only apparent, cannot by any means be called an unnatural one, and it is interesting to consider the counterparts it finds among what is known of the opinions of the oldest Greek philosophers.* So it is reported of Anaximenes that he supposed the sun not to descend below the earth, but to describe circles above it and to pass during the night behind high mountains situated in the north; an exact parallel to the Indian conception. Of Xenophanes we hear that he declared the sun, moon and stars to be only accumulations of burning vapour, fiery clouds kindling and extinguishing themselves by turns, that these clouds move in reality in straight lines and only appear to us to rise and to set in consequence of their varying distance, in the same way as the common clouds seem to rise from the horizon when they first become visible to us and seem to sink under the horizon when they pass out of our field of vision. These opinions too find their exact counterpart in the Súryaprajñapti and kindred works where the rising and setting of the heavenly bodies is declared to be an appearance caused by their consecutive approaching and receding, and where their movement is said to take place not indeed in a straight line but at any rate in a plane parallel to the plane of the earth. The first mentioned opinion of Xenophanes about the constitution of the heavenly bodies finds its analogon in one of the different pratipattis, mentioned in the Súryaprajñapti, according to which the sun is nothing but a "kiraṇasaṃgháta," an accumulation of rays forming itself every morning in the east and dissolving itself in the evening in the west. The cognate views held by Heraclitus concerning the nature of the sun are well known. Of Xenophanes it is further reported that he supposed different climes and zones of the earth, far distant from each other, to have different suns and moons; which is another striking parallel to the view held by the Jainas with reference to the different suns, moons and stars illuminating the different concentric dvípas of which the earth consists. In both cases the assumption of the rising and setting of the heavenly bodies being an appearance, caused by their becoming visible and invisible in turns when having approached us or receded from us by a certain amount, seems to have lead to the conclusion that the light of the one sun and the one moon appearing to us cannot illumine the whole vast earth, since it only reaches to a certain limited

* For the particulars mentioned in the following: comp. Mullach's collection of the fragments of the Greek philosophers, Zeller's history of Greek philosophy, Lewis's historical survey of the Astronomy of the Ancients.

distance.—On the other hand it is true enough that, notwithstanding these similarities of Indian and Greek ideas, books of the nature of the Súryaprajñapti serve clearly to show the difference of the mental tendencies of the two nations. Both in an early age conceived plausible theories, in reality devoid of foundation, by which they tried to account for puzzling phenomena ; but while the Greeks controlled their theories by means of continued observation of the phenomena themselves and replaced them by new ones, as soon as they perceived that the two were not in harmony, the Hindus religiously preserved the generalisations hastily formed at an early period, and instead of attempting to rectify them, proceeded to deduce from them all kinds of imaginary consequences. The absurdity of systems of the nature of the Jaina system lies not in the leading conceptions—these can as a rule be accounted for in a more or less satisfactory manner—but in the minute detail into which the followers of the system have without scruple and hesitation worked it out.

Before this paper is brought to a conclusion, the writer wishes to draw attention to the—in his opinion very striking—resemblance which the cosmological and astronomical conceptions, contained in an old Chinese book, bear to the early Indian ideas on the same subject, more particularly to the Jaina system as expounded in the Súryaprajñapti. The Chinese book alluded to is the Tcheou-Pei of which a complete translation was published for the first time by Edward Biot in the Journal Asiatique for 1841, pp. 592—639. It consists of two parts of different ages ; the first part which apparently is of considerable antiquity, has been known since the time of Gaubil, who inserted a translation of it into his history of Chinese astronomy, published in the Lettres éd fiantes ; that part, as is well known, shows that the ancient Chinese were acquainted with the theorem about the square of the hypothenuse of a right-angled triangle. The second and more recent part, which E. Biot thinks cannot be later than the end of the second century of our era, contains a sort of cosmological and astronomical system, and here the traits of resemblance alluded to above are to be found. As the arrangement of topics in the Tcheou-Pei is by no means systematic, so that it is not easy to form a clear conception of the essential points, a short abstract of the work, as far as it lends itself to a comparison with the Jaina system, is given in the following.

According to the Tcheou-Pei the sun describes during the course of the year a number of concentric circles of varying diameter round the pole of the sky. On the day of the summer solstice the diameter of this circle is smallest ; it then increases during the following months, up to the day of the winter solstice when it reaches its maximum. Beginning from this day the solar circles again decrease, until on the day of the next summer solstice they have reached the original minimum. On the day of the winter solstice the diameter of the solar circle amounts to 476,000 li (the li is a certain Chinese measure of length); its circumference to $3 \times 476{,}000 = 1{,}428{,}000$ li. The corresponding numbers for the circle, described on the day of the summer solstice, are 238,000 and 714,000. Between the innermost and the outermost circle there lie five other circles, which the sun describes in the months intervening between the two solstices, so that there are altogether seven circles; the six intervals between these are said to correspond to the months of the year ($2 \times 6 = 12$). So it appears that the Tcheou-Pei assumes separate solar circles for each month only, not for each day. Each circle is at the distance of $19{,}833\frac{1}{3}$ li from the two neighbouring circles.

The terrestrial place for which all the calculations of the Tcheou-pei are made is said to have such a situation that it is distant 16,000 li from the spot lying perpendicularly under the sun on the day of the summer solstice and 135,000 li from the spot lying perpendicularly under the sun on the day of the winter solstice; the distance of the place of observation from the pole, *i. e.*, the spot at the centre of the earth which lies perpendicularly under the celestial pole, is said to amount to 103,000 li. Round the terrestrial pole there extends a circle of 11,500 li radius, which is the terrestrial counterpart of the circle described by the polar star round the celestial pole. The light of the sun extends 167,000 li in each direction, so that on the day of the winter solstice when the sun moves in the exterior circle it extends at midday only 32,000 li beyond the place of observation and so does not reach up to the polar circle. On the days of the two equinoxes when the sun is moving in the fourth circle—the diameter of which amounts to 357,000 li—the rays of the sun just reach up to the polar circle. On the day of the summer solstice when the sun moves in the interior circle his rays reach beyond the pole to the extent of 48,000 li, so that then the whole polar circle is continually illuminated. When the sun in his daily revolution has reached the extreme north point, it is midday in the northern region and midnight in the southern region; when he has reached the east point, it is midday in the eastern, midnight in the western region; when he has reached the south point, it is midday in the southern, midnight in the northern region; when he has reached the west point, it is midday in the western, midnight in the eastern region. As the light of the sun always reaches 167,000 li each way, we must add $2 \times 167{,}000$ to the diameter of the circle, described on the day of the winter solstice, in order to obtain the diameter of the circle representing the outmost limit reached by the rays of the sun; the diameter of this circle is therefore 810,000 li.

On the day of the winter solstice the space illuminated by the sun stands to the space not reached by his rays in the relation of three to nine; this proportion is to be reversed for the day of the summer solstice. The day of the winter solstice is the shortest during the year; the day of the summer solstice the longest. On the day of the winter solstice the shadow of the gnomon is 13·5 feet long; beginning from this day it goes on diminishing by equal quantities during equal spaces of time up to the day of the summer solstice when its length is reduced to 1·6 feet. It then increases again in the same uniform manner up to the day of the next winter solstice.

The circumference of the sky is divided into twenty-eight stellar divisions of unequal extent, through the circle of which sun and moon are performing their revolutions. Kien-nieou is the asterism in which the sun stands at the winter solstice; Leou the asterism of the vernal equinox etc. A procedure is taught how to find the place of the sun at any time. The whole circle of the asterisms is divided into $365\frac{1}{4}$ degrees corresponding to the number of the days of the year. A year is the period which the sun requires for returning to the same star from which he had set out. The meeting of sun and moon constitutes a month. A period of nineteen years of $365\frac{1}{4}$ days each contains 235 lunations. Arithmetical rules are given how to find the place of the moon at the beginning of each year etc.

The Tcheou-pei contains some additional matter about observations of the polar star etc., but by far the greater part of the topics it treats have been touched in the above summary. The similarity of this system and the old Indian systems particularly, as far as some details are concerned, the Jaina system is obvious. The same supposition is made use of in both to account for the alternating progress of the sun towards the north and the south. In the Jaina system the sun revolves round Mount Meru, in the Chinese system, to which the idea of a central mountain seems to be foreign, round the pole of the sky; Mount Meru finds, however, a curious counterpart in the Chinese polar circle, the projection of the circle described by the polar star. Both systems state the dimensions of the circles described by the sun; both state in figures the extent to which the rays of the sun reach. Both hold the same opinion about the alternation of day and night in the different parts of the earth. Both are interested in finding out what places sun and moon occupy in the circle of the nakshatras. Both teach the increase of the shadow by an equal quantity in each month. On the other hand there are important points in which the two systems differ. The Chinese appear from comparatively ancient times to have had a knowledge of the fact that the approximate duration of the solar year amounts to $365\frac{1}{4}$ years and that a period of nineteen years comprises 325 lunations. This of course makes the system of the Tcheou-pei to differ from the Jaina system in all those details which depend on the fundamental period and the advantage is of course altogether on the side of the Chinese. On the whole the Tcheou-pei is much superior to works of the stamp of the Súryaprajñapti, as in midst of all the fantastical and unfounded ideas it contains there are found some positive elements, observations of stars which admit of control etc., features altogether absent in the Súryaprajñapti. But in spite of these points of difference the similarities of the two works remain striking, especially if we take as one member of the comparison not the Súryaprajñapti itself but some hypothetical older work of the same class, less elevate and more moolerate in the statement of dimensions, figures etc. That such works if not existent at present must have existed at same earlier period is manifest from the remarks the Súryaprajñapti in many places makes about the opinions of other teachers, several of which have been extracted above. That two different chronological periods, the quinquennial yuga and so called Metanic cycle, from the foundation of the two systems does after all not interfere very much with their similarity. We might imagine the Jainas adopting the more correct cycle of nineteen years instead of the quinquennial one and work out all the new details necessitated by such a change, calculate all the places of moon and full moon during nineteen years instead of five etc., nevertheless the new system would immediately suggest the idea of the old one. An essential feature in the resemblance of the Chinese and the Hindu system is more over the circumstance of both limiting themselves to the treatment of a certain number of topics. The following paragraph of the Tcheou-pei (p. 603) which shortly states the questions to be treated in the work, might with hardly any change be taken as a summary of the contents of the Súryaprajñapti.

"I have heard people speak of the knowledge of the great man. I have heard it said that he knows the height and the size of the sun, the extent which his light illuminates, the quantity by which he moves in the course of one day, the quantity be which he recedes and approaches, the extent which the eye of man embraces, the position of the four extreme (cardinal) points, the divisions of the stars arranged in order, the breadth and length of the sky and the earth."

The questlon whether the similarity of the two systems justifies us in assuming a historical connexion between the two or would be an interesting one, but cannot be treated in this place, especially as its solution could only be attempted together with the solution of a number of cognate problems.